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<p>(21) International Application Number: PCT/US89/05505 (22) International Filing Date: 5 December 1989 (05.12.89) (30) Priority data: 279,537 5 December 1988 (05.12.88) US (60) Parent Application or Grant (63) Related by Continuation US 279,537 (CIP) Filed on 5 December 1988 (05.12.88) (71) Applicants (for all designated States except US): HOUSTON BIOTECHNOLOGY INCORPORATED [US/US]; 3608 Research Forest Drive, The Woodlands, TX 77381 (US). E.R. SQUIBB & SONS, INC. [US/US]; P.O. Box 4000, Princeton, NJ 08543-4000 (US). (72) Inventors; and (75) Inventors/Applicants (for US only) : CROSSON, Craig, E. [US/US]; 25 Dovewood Place, The Woodlands, TX 77380 (US). POTTER, David, E. [US/US]; 15 West Shaker Court, The Woodlands, TX 77380 (US). ONDET-TI, Miguel, A. [US/US]; 79 Hemlock Circle, Princeton, NJ 08540 (US). FLOYD, David [US/US]; Route 1, Box 404M, Lawrenceville, NJ 08648 (US). ABERG, Gunner [US/US]; 519 Bergen Street, Lawrenceville, NJ 08648 (US).</p>		<p>(74) Agents: DELFLACHE, Marc, L. et al.; Pravel, Gambrell, Hewitt, Kimball & Krieger, Tenth Floor, 1177 West Loop South, Houston, TX 77027 (US). (81) Designated States: AT (European patent), AU, BB, BE (European patent), BF (OAPI patent), BG, BJ (OAPI patent), BR, CF (OAPI patent), CG (OAPI patent), CH (European patent), CM (OAPI patent), DE (European patent), DK, ES (European patent), FI, FR (European patent), GA (OAPI patent), GB (European patent), HU, IT (European patent), JP, KP, KR, LK, LU (European patent), MC, MG, ML (OAPI patent), MR (OAPI patent), MW, NL (European patent), NO, RO, SD, SE (European patent), SN (OAPI patent), SU, TD (OAPI patent), TG (OAPI patent), US. Published With international search report.</p>
<p>(54) Title: THERAPEUTIC USE OF DIHYDROPYRIMIDONES AND BENZAZEPINE AND BENZOTHIAZEPINE DERIVATIVES IN RETINAL OR OPTIC NERVE DYSFUNCTION</p> <p>(57) Abstract</p> <p>Ischemia or edema of the retina or optic nerve results in retinal dysfunction. This retinal dysfunction can be associated with the activation of calcium channels. The prophylactic or therapeutic administration of compounds to block these processes can ameliorate or prevent retinal dysfunction. These compounds include the dihydropyrimidones, benzazepine and benzothiazepine derivative classes selected of calcium channel antagonists. Therapeutic treatment with compounds include dihydropyrimidones and benzazepines and benzothiazepine derivatives as calcium channel antagonists. Such compounds exhibit a prophylactic effect to ischemia and edema of the retina or optic nerve.</p>		

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THERAPEUTIC USE OF
DIHYDROPYRIMIDONES AND BENZAZEPINE AND
BENZOTHIAZEPINE DERIVATIVES IN
RETINAL OR OPTIC NERVE DYSFUNCTION

Technical Field

The subject invention is drawn to the use of dihydropyrimidones and benzazepine and benzothiazepine derivatives as calcium channel antagonists in the treatment of retinal and optic nerve dysfunction.

Background of the Invention

Retinal vascular disease and ischemia are associated with malfunction of neuroendocrine regulation and autoregulation of the choroidal and retinal circulations, respectively. It has been postulated that excessive elevation of intracellular calcium (calcium overload) in retinal blood vessels and neurons may be involved in the pathogenesis of retinal vasculopathy, ischemia and ultimately, retinal damage. Some specific pathologic events triggered by excess intracellular calcium ions include: generation of free radicals, activation of proteases, endonucleases and lipases, and interference with energy production in mitochondria.

Blood flow to the retina is supplied by two separate vascular systems: the retinal vessels supplying the inner retinal layers and choroidal vessels supplying the outer retinal layers. In primates, approximately 35% of the total retinal blood flow is derived from the retinal vessels, while 65% is from the choroidal vessels.

Although the choroidal blood flow is of greater magnitude, retinal ischemia is usually associated with a reduction of flow in the inner retinal vessels. This greater propensity for ischemia in the inner retina may result from several factors: (1) the high rate of choroidal blood flow over that required to meet the metabolic needs of the outer retina; (2) the large diameter capillaries in the choroid are less likely to be occluded by emboli; (3) the lack of anastomoses in the retinal vessels; and (4) the larger percentage of oxygen extracted from the retinal arterioles/capillaries (35%) as compared to the choroidal circulation (3-4%). To maintain an adequate supply of nutrients to the inner retina under various systemic and ocular conditions, blood flow through normal retinal vessels is highly autoregulated by metabolic (oxygen and carbon dioxide), myogenic and possibly local hormonal (paracrine and autocrine) factors.

A number of systemic and ocular disorders have been associated with ischemic conditions of the retina or optic nerve. Ocular manifestations of systemic disorders include: diabetes, atherosclerosis, hyperlipidemia, and hypertension. Specific ocular disorders include: retinitis of AIDS, macular degeneration, anterior ischemic optic neuropathy, ocular hypertension, glaucoma, retinopathy of prematurity, retinal vessel occlusion, diabetic retinopathy and hypertensive retinopathy. In addition, edemic conditions of the retina or optic nerve are evidenced in diabetes, hypertension and cystoid macular edema. Newer evidence also suggests that excessive influx of calcium ions into vascular and neuronal tissue is a primary contributor to the pathogenesis of ischemic injury and the development of vasculopathy and neuropathy.

It is therefore of substantial interest to identify compounds which may be used in the therapeutic treatment of or prophylactic treatment against vasculopathies and neuropathies associated with the eye.

Further, it is of great interest to develop a reproducible and sensitive bioassay which is a good predictor of the utility of a compound as a therapeutic for various ischemic retinopathies. Desirable characteristics of such a bioassay are the use of relatively small animals with ocular vasculature and neural retina similar to that of humans, particularly rodentiae, which provides for constitutive retinal dysfunction or the ability to reproducibly induce such dysfunction, ease of access to the major arteries supplying the retina, ease of identifying the existence of the dysfunction and the effect of addition of a candidate compound on occurrence of such dysfunction or the effect on progression of such dysfunction.

15 Relevant Literature

The publications cited herein are incorporated by reference as if each publication were specifically and individually indicated to be incorporated by reference.

Choi (1985) Neuroscience Letters 58:293-297, described the calcium dependence of glutamate neurotoxicity in cortical cell culture. Meldrum (1985) Clinical Science 68:113-122, describes potential therapeutic applications of antagonists of excitatory amino acid neurotransmitters. Sinclair et al., (1982) J. American Academy of Ophthalmology 89:748-750, describe retinal vascular autoregulation in diabetes mellitus. Rhie et al., (1982) Diabetes 31:1056-1060, describe retinal vascular reactivity to norepinephrine and angiotensin II in normals and diabetics. Fleckenstein et al., (1985) Am. J. Cardiol. 56:3H-14H, describe the experimental basis of long-term therapy of arterial hypertension with calcium antagonists. Fleckenstein et al., (1987) Ibid. 59:177B-187B, describe future directions in the use of calcium antagonists in the treatment of cardiovascular disease. Godfraind (1987) Ibid. 59:11B-23B, provides a classification of calcium antagonists. Fleckenstein et al., (1987) TIPS 8:496-501,

- describe investigation of the role of calcium in the pathogenesis of experimental arteriosclerosis. Katz and Leach (1987) J. Clin. Pharmacol. 27:825-834, describe a therapeutic application of 1,4-dihydropyridine calcium channel blockers. Gelmers et al., (1988) N. Engl. J. Med. 318:203-207, describe an investigation of nimodipine in acute ischemic stroke. Cook and Hof (1988) Br. J. Pharmacol. 93:121-131, describe the cardiovascular effects of apamin and BRL 34915 in rats and rabbits. Nihard (1982) Angiology 33:37-45, describes the effect of calcium-entry-blockers on arterioles, capillaries and venules of the retina. Corbiere, French Patent No. 2,585,574 describes the use of ocular pharmaceuticals containing (nitrophenyl)dihydropyridinedicarboxylates. Triggles and Janis (1987) Ann. Rev. Pharmacol. Toxicol. 27:347-369, describe structure-function relationships for calcium channel ligands, particularly 1,4-dihydropyridines.

- Articles concerned with rat models for chronic or acute retinal dysfunction include von Sallmann and Grimes (1974) Investigative Ophthalmology 13:1010-1015; Frank et al., (1986) Science 231:376-378 and Stefansson et al., (1988) Invest. Ophthalmol. Vis. Sci. 29:1050-1055.

SUMMARY OF THE INVENTION

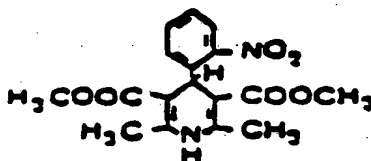
- Azaheterocycle calcium entry blockers are useful in the treatment of subjects, such as mammals, including man, suffering from ischemia or edema of the retina or optic nerve. Such calcium entry blockers may be grouped as calcium channel antagonists and excitatory amino acid receptor antagonists. Associated with retinal dysfunction are techniques for assessing neural retinal function. In addition, such compounds exhibit prophylactic effects in preventing such conditions. Methods are further provided for screening compounds associated with regulation of calcium channels by employing in vivo bioassays using rats with inducible retinal dysfunction.

DESCRIPTION OF THE SPECIFIC EMBODIMENTS

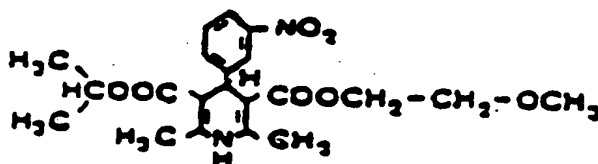
Compounds associated, either directly or indirectly, with the modulation of calcium entry exhibit a therapeutic or prophylactic effect to subjects suffering from ischemia or edema of the retina or optic nerve. Such conditions are evidenced in the systemic and ocular ischemic and edemic disorders cited above.

These compounds may be divided into two categories. The first are the calcium channel antagonists, which may be further divided into dihydropyridines, dihydropyrimidones, diphenylpiperazines, benzazepines and benzothiazepines derivatives. The second category are excitatory amino acid antagonists, which include NMDA, quisqualate and kainate receptor antagonists.

Among dihydropyridines of interest are nifedipine, having the structural formula:

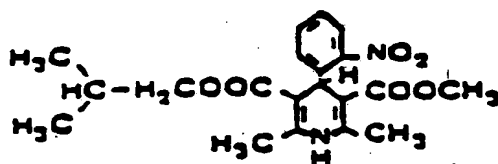


nimodipine, having the structural formula:

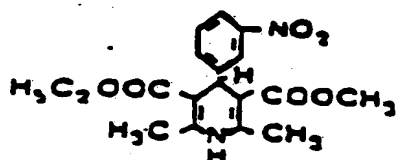


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nisoldipine, having structural formula:

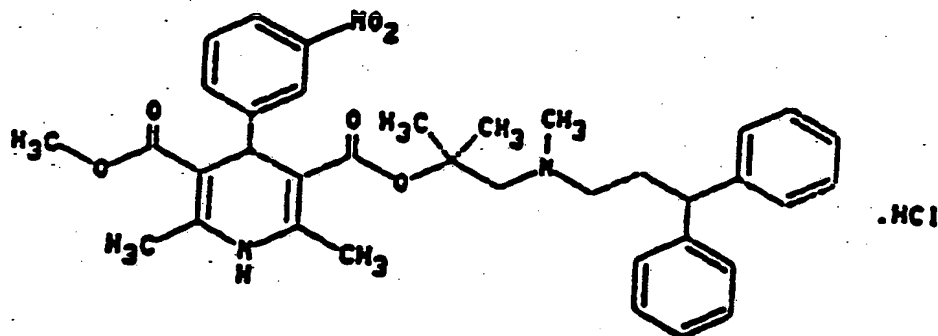


nitrendipine, having structural formula:

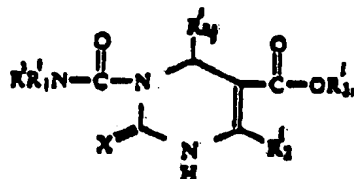


; and

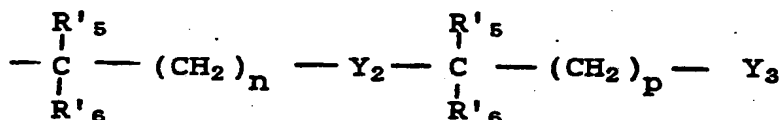
1,1-Dimethyl-2-[N-(3,3-diphenylpropyl)-N-methyl-
 5 amino]ethyl methyl 1,4-dihydro-2,6-dimethyl-4-
 (3-nitrophenyl)-3,5-pyridinedicarboxylate hydrochloride,
 having the structural formula:



Among dihydropyrimidones are those of the formula:

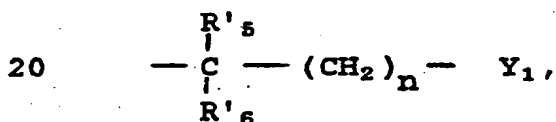


and pharmaceutically acceptable salts thereof wherein X is oxygen or sulfur; R' is hydrogen, alkyl, cycloalkyl, aryl, or arylalkyl and R'1 is hydrogen, alkyl, cycloalkyl, aryl, heterocyclo,



or halo substituted alkyl, or R' and R'1 taken together with the nitrogen atom to which they are attached are 1-pyrrolidinyl, 1-piperidinyl, 1-azepinyl, 4-morpholinyl, 4-thiamorpholinyl, 1-piperazinyl, 4-alkyl-1-piperazinyl, 4-arylalkyl-1-piperazinyl, 4-diarylalkyl-1-piperazinyl or 1-pyrrolidinyl, 1-piperidinyl, or 1-azepinyl substituted with alkyl, alkoxy, alkylthio, halo, trifluoromethyl or hydroxy;

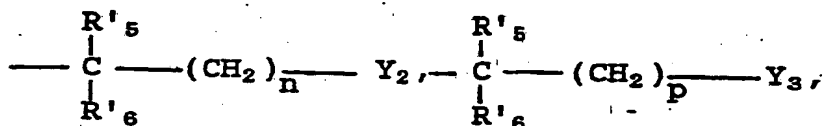
R'2 is hydrogen, alkyl, alkenyl, alkynyl, cycloalkyl, aryl,



or halo substituted alkyl;

R'3 is hydrogen, alkyl, cycloalkyl, aryl, heterocyclo,

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or halo substituted alkyl;

5 R'₄ is aryl or heterocyclo;

R'₅ and R'₆ are each independently hydrogen, alkyl,

---(CH₂)_q---aryl or ---(CH₂)_q---cycloalkyl;

Y₁ is cycloalkyl, aryl, heterocyclo, hydroxyl, alkoxy,
aryl---(CH₂)_m---O---, mercapto, alkylthio,

10 aryl---(CH₂)_m---S---, amino, substituted amino,
carbamoyl,

(Substituted amino)-C(=O)-, heterocyclo-(CH₂)_m-C(=O)-

15 carboxyl, alkoxycarbonyl, alkyl-C(=O)-, aryl-(CH₂)_m-C(=O)-

alkyl-C(=O)-O- or aryl-(CH₂)_m-C(=O)-O-

Y₂ is cycloalkyl, aryl, heterocyclo, carbamoyl,

20 (substituted amino)-C(=O)-, carboxyl, alkoxycarbonyl,

alkyl-C(=O)-, aryl-(CH₂)_m-C(=O)- or heterocyclo-(CH₂)_m-C(=O)-;

Y₃ is hydroxyl, alkoxy, aryl-(CH₂)_m-O-, mercapto,
alkylthio, aryl-(CH₂)_m-S-,

25 alkyl-C(=O)-O-, aryl-(CH₂)_m-C(=O)-O-,
amino or substituted amino;

q is 0, 1, 2 or 3;

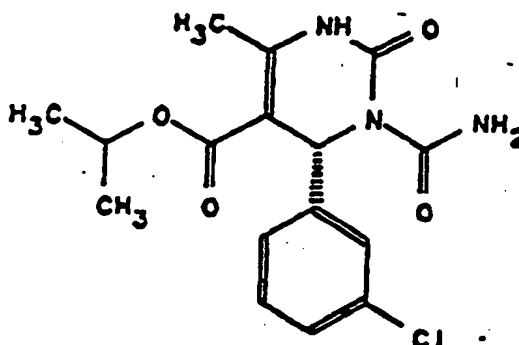
m is 0 or an integer of 1 to 6;

30 n is 0 or an integer of 1 to 5; and

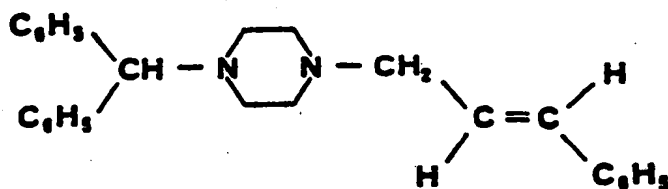
p is an integer of 1 to 5.

Especially preferred is (R)-1-(Aminocarbonyl)-6-(3-chlorophenyl)-1,2,3,6-tetrahydro-4-methyl-2-oxo-

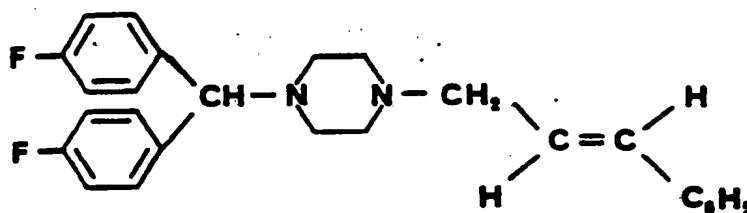
5-pyrimidine-carboxylic acid, 1-methylethyl ester, having the structural formula:



Among diphenylpiperazines of interest are cinnarizine and flunarizine, having structural formula:



5 and



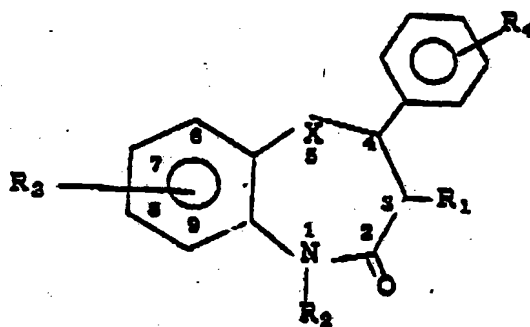
In addition, the calcium entry blockers of this invention may include such calcium channel antagonists as

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phenylalkylamines, such as verapamil and adipamil, benzothiazepines, such as diltiazem, clentiazem and naltiazem and benzazepines.

Benzazepine and benzothiazepine derivatives of interest include those of the formula:

I.



I

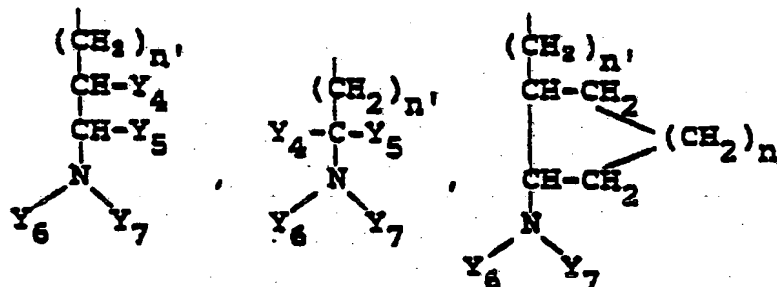
and the pharmaceutically acceptable salts thereof, wherein:

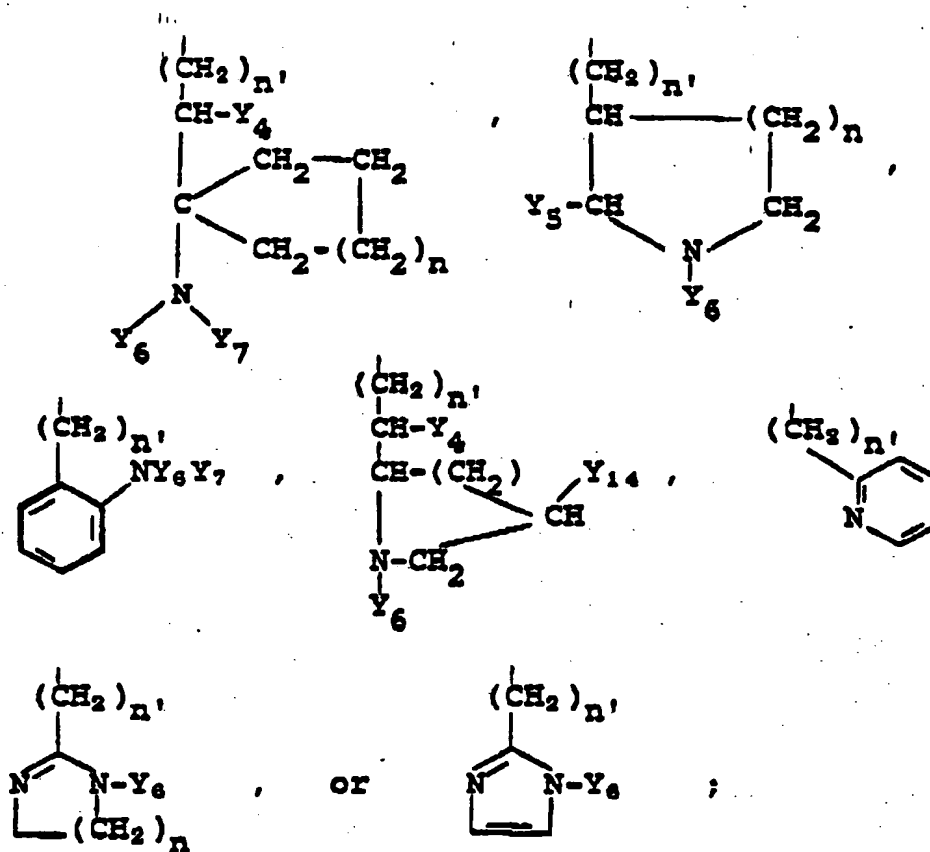
X is $-\text{CH}_2-$ or $-\text{S}-$;

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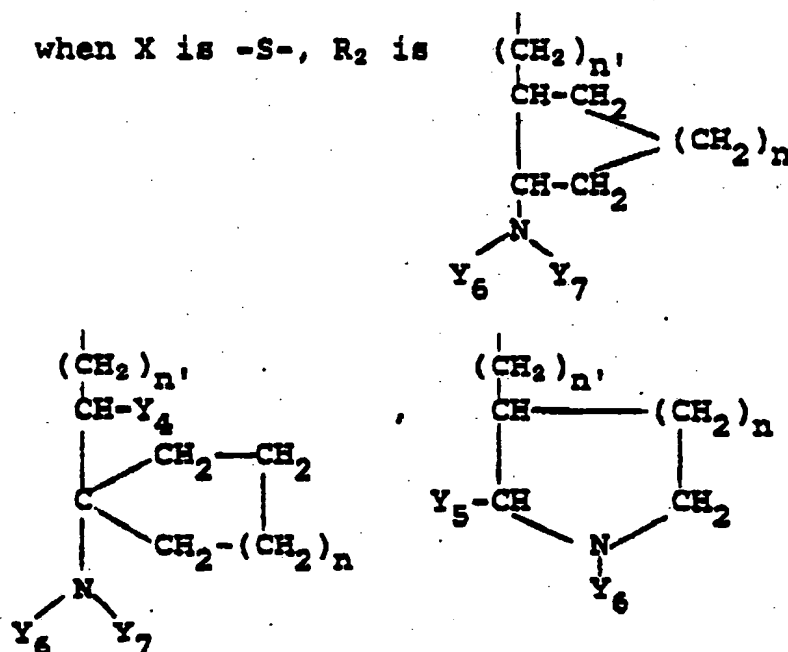
R_1 is $-\text{CH}-$ or $-\text{O}-\text{Y}_3$;
 $\begin{array}{c} \text{Y}_1 \\ | \\ -\text{CH} \\ | \\ \text{Y}_2 \end{array}$

when X is $-\text{CH}_2-$, R_2 is

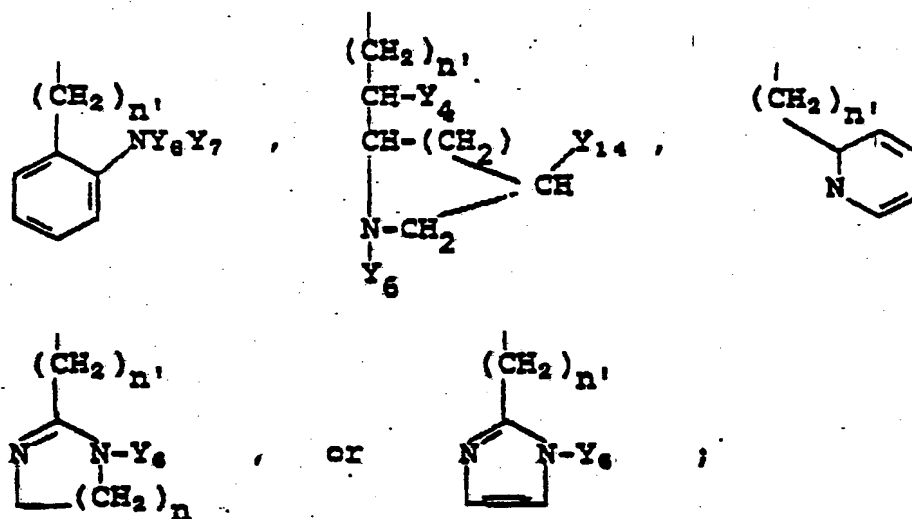




when X is -S-, R_2 is



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R_3 and R_4 are each independently hydrogen, halogen, alkyl, alkoxy, aryloxy, arylalkoxy, arylalkyl, cyano, hydroxy, alkanoyloxy,

5 $-O-\overset{\text{O}}{\parallel}{C}-NY_8Y_9$, fluoro substituted alkoxy, fluoro substituted alkyl, (cycloalkyl)alkoxy, $-NO_2$,

$-NY_{10}Y_{11}$, $-S(O)_m$ alkyl, $-S(O)_m$ aryl, $-\overset{\text{O}}{\parallel}{C}-Y_{12}$ or

10 $-O-\overset{\text{O}}{\parallel}{C}-Y_{13}$;

n or n' are independently 0, 1, 2, or 3;

m is 0, 1 or 2;

Y_1 and Y_2 are independently hydrogen or alkyl, Y_1 is hydrogen and Y_2 is alkenyl, alkynyl, aryl, heteroaryl, or
15 cycloalkyl, or Y_1 and Y_2 together with the carbon atom to which they are attached are cycloalkyl;

Y_3 is hydrogen, alkyl, alkanoyl, alkenyl,

arylcarbonyl, heteroarylcarbonyl, or $-\overset{\text{O}}{\parallel}{C}-NY_8Y_9$;

20 Y_4 and Y_5 are each independently hydrogen, alkyl, aryl or arylalkyl, provided that when both are present they are not both hydrogen, and provided further that when both are attached to the same carbon atom neither of them is hydrogen;

25 Y_6 and Y_7 are each independently hydrogen, alkyl, cycloalkyl or arylalkyl or Y_6 and Y_7 together with the nitrogen atom to which they are attached are azetidiny, pyrrolidinyl, piperidinyl, or morpholinyl;

Y_8 and Y_9 are each independently hydrogen, alkyl, 30 aryl or heteroaryl, or Y_8 and Y_9 together with the nitrogen atom to which they are attached are pyrrolidinyl, piperidinyl or morpholinyl;

Y_{10} and Y_{11} are each independently hydrogen, alkyl, alkanoyl, arylcarbonyl, heteroarylcarbonyl,

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or $\begin{array}{c} \text{O} \\ \parallel \\ -\text{C}-\text{NY}_8\text{Y}_9 \end{array}$

Y_{12} is hydroxy, alkoxy, aryloxy, amino, alkylamino or dialkylamino;

5 Y_{13} is alkyl, alkoxy, or aryloxy; and

Y_{14} is hydrogen, hydroxy, alkoxy, aryloxy or arylalkoxy.

Listed below are definitions of various terms used to describe the compounds of this invention. These definitions apply to the terms as they are used throughout the specification (unless they are otherwise limited in specific instances either individually or as a part of a larger group.)

The terms "alkyl" and "alkoxy" refer to both straight and branched chain groups. Those groups having 1 to 10 carbon atoms are preferred.

The term "alkenyl" refers to both straight and branched chain groups. Those groups having 2 to 10 carbon atoms are preferred.

The term "aryl" refers to phenyl and substituted phenyl. Exemplary substituted phenyl groups are phenyl groups substituted with 1, 2 or 3 amino ($-\text{NH}_2$), alkylamino, dialkylamino, nitro, halogen, hydroxyl, trifluoromethyl, alkyl (of 1 to 4 carbon atoms), alkoxy (of 1 to 4 carbon atoms), alkylthio, (of 1 to 4 carbon atoms), alkanoyloxy, carbonyl, or carboxyl groups.

The term "alkanoyl" refers to groups having the formula $\text{alkyl}-\overset{\text{O}}{\underset{\parallel}{\text{C}}}-$. Those alkanoyl groups having 2 to 11 carbon atoms are preferred.

The term "heteroaryl" refers to an aromatic heterocyclic group having at least one heteroatom in the ring. Preferred groups are pyridinyl, pyrrolyl, imidazolyl, furyl, thienyl, oxazolyl or thiazolyl.

The term "cycloalkyl" refers to groups having 3, 4, 5, 6 or 7 carbon atoms.

The term "halogen" refers to fluorine, chlorine, bromine and iodine.

The terms "fluoro substituted alkyl" and "fluoro substituted alkoxy" refer to alkyl and alkoxy groups (as described above) in which one or more hydrogens have been replaced by fluorine atoms. Exemplary groups are trifluoromethyl, 2,2,2-trifluoroethyl, pentafluoroethyl, fluoromethoxy, difluoromethoxy, etc.

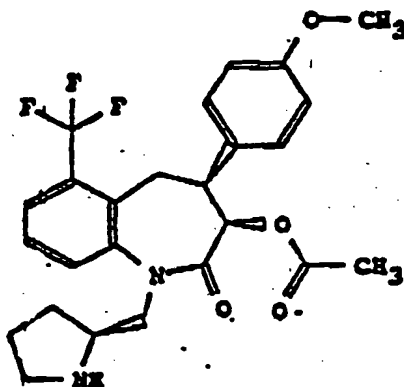
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5 The compounds of formula I form acid-addition salts with inorganic and organic acids. These acid-addition salts frequently provide useful means for isolating the products from reaction mixtures by forming the salt in a medium in which it is insoluble. The free base may then be obtained by neutralization, e.g., with a base such as sodium hydroxide. Any other salt may then be formed from the free base and the appropriate inorganic or organic acid. Illustrative are the hydrohalides, especially the hydrochloride and hydrobromide, sulfate, nitrate, phosphate, borate, acetate, tartrate, maleate, citrate, succinate, benzoate, ascorbate, salicylate, methanesulfonate, benzenesulfonate, toluenesulfonate and the like.

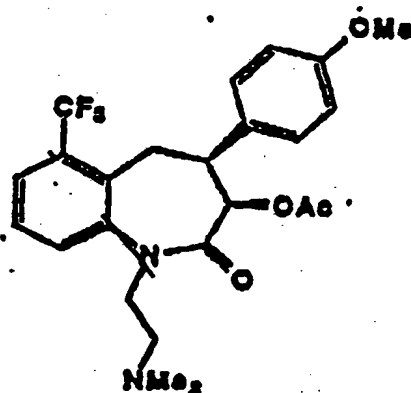
15 The carbon atoms in the 3 and 4-positions of the benzazepine nucleus and, carbon atoms in the 2 and 3-positions of the benzothiazepine nucleus, of the compounds of the formula I are asymmetric carbons. The compounds of formula I, therefore, exist in enantiomeric and diastereomeric forms and as racemic mixtures thereof. All are within the scope of this invention. It is believed that those compounds of formula I which have the cis configuration are the most potent and are therefore preferred.

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Particularly preferred as a suitable benzazepines within this invention is the compound [3R-[1(S*),3<a,4<a]]-3-(Acetyloxy)-1,3,4,5-tetrahydro-4-(4-methoxyphenyl)-1-(2-pyrrolidinyl-methyl)-6-(trifluoromethyl)-2H-1-benzazepin-2-one, 5 monohydrochloride having the structural formula:



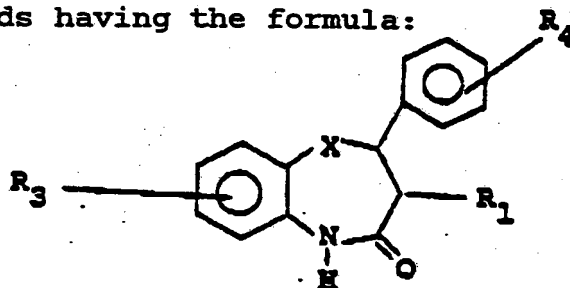
Additionally, compounds disclosed in U.S. Patent No. 4,748,239 including (3R-cis)-3-(Acetyloxy)-1-[2-(dimethylamino)ethyl]-1,3,4,5- 10 tetrahydro-4-(4-methoxyphenyl)-6-(trifluoromethyl)-2H-1-benzazepin-2-one, monohydrochloride the structure:



are useful herein.

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Calcium channel antagonists which may be employed in this invention are produced by conventional methods well known in the art. In particular the benzothiazepine and benzazepine derivatives can be prepared from the
 5 corresponding compounds having the formula:



The preparation of the racemic and nonracemic forms of the compounds of formula II when X is CH₂ is described in United States Patent 4,752,645 issued

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June 21, 1988 for those compounds wherein R₁ is $\begin{array}{c} Y_1 \\ | \\ -CH \\ | \\ Y_2 \end{array}$,

and in United States Patent 4,748,239, issued May 31, 1988 for those compounds wherein R₁ is -OY₃ and Y₃ is hydrogen.

15

Compounds of formula II where X is S and R₁ is OY₃ are prepared as described in U.S. Patent 3,562,257 issued February 9, 1971.

20

Compounds of formula II where X is S and R₁ is $\begin{array}{c} Y_1 \\ | \\ -CH \\ | \\ Y_2 \end{array}$

are prepared as described in U.S. Patent 4,694,002, issued September 15, 1987. Compounds of formula II wherein R₁ is -O-Y₃ and Y₃ is other than hydrogen can be obtained by alkylation or acylation (using conventional techniques) of
 25 the corresponding compound of the formula II wherein R₁ is -OH.

The compounds of formula II where R₁ is OH can be prepared in nonracemic form by reacting the racemic compound of formula II where R₁ is OH with a nonracemic

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acid or amino acid Z_1 $\begin{array}{c} \diagup \\ Z \\ \diagdown \end{array}$ CO_2H where Z and Z_1 are different, using conventional acylation techniques such as carbodiimide with a catalyst such as

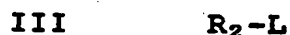
5 dimethylaminopyridine, to give a mixture of

diastereomeric compounds II wherein R_1 is $\begin{array}{c} O \\ || \\ -O-C-CH_2-Z \\ | \\ Z_1 \end{array}$.

This mixture of diastereomeric compounds can be separated

10 by those skilled in the art, using chromatographic techniques or crystallization. The nonracemic compounds of formula II where R_1 is OH are obtained from the purified diastereomers by hydrolysis with a base such as sodium hydroxide or sodium methoxide.

15 Treatment of a compound of formula II with a base (e.g., sodium hydride or cesium carbonate) in an inert solvent (e.g., dimethylformamide or dimethylsulfoxide) followed by reaction with a compound of the formula:



20 (where L is a leaving group such as halo or tosyloxy) yields the corresponding product of formula I.

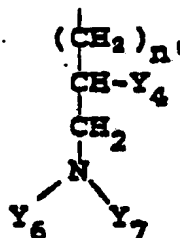
Alternatively, a compound of formula I can be prepared by reacting a compound of formula II with one of

25 formula III under phase transfer conditions in a mixture of water and dichloromethane or toluene in the presence of an appropriate base (e.g., barium hydroxide or sodium hydroxide) and catalyst (e.g., benzyl trimethylammonium chloride or tetra-n-butylammonium hydrogen sulfate).

Alternatively, the products of formula I wherein R_1

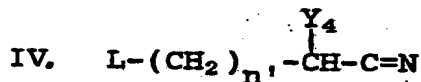
30 is $-OH$ can be alkylated or acylated (using conventional techniques) to obtain those products of formula I wherein R_1 is $-O-Y_3$ and Y_3 is other than hydrogen.

An additional procedure for preparing the compounds of formula I wherein R_2 is:

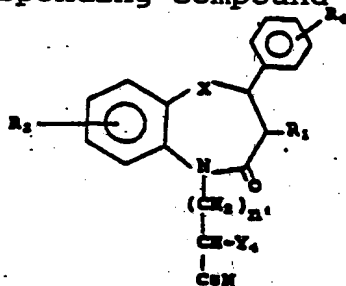


comprises treating a compound of formula II with an alkali metal hydride (e.g., sodium hydride) in an inert solvent (e.g., dimethylformamide or dimethylsulfoxide) followed by reaction with a compound of the formula:

5



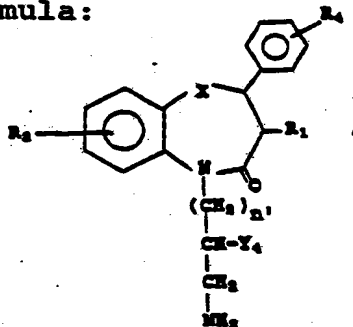
to obtain the corresponding compound having the formula:
V.



Reduction of a compound of formula V using, for example, catalytic hydrogenation (e.g., rhodium on alumina) yields the corresponding product of formula I having the formula:

10

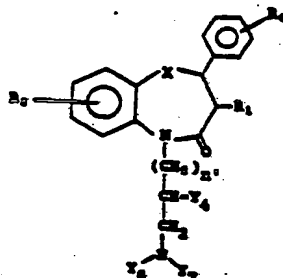
VI.



Reductive amination of a compound of formula VI with the appropriate aldehyde or ketone using a chemical reducing agent (e.g., sodium cyanoborohydride) yields the corresponding product of formula I having the formula:

15

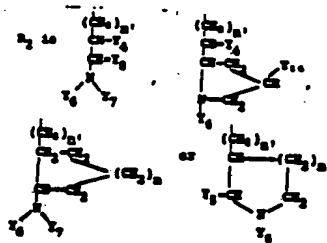
VII.



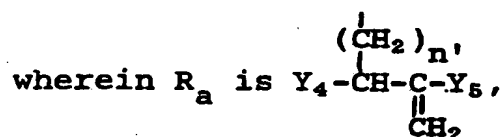
wherein at least one of Y₆ and Y₇ is other than hydrogen.

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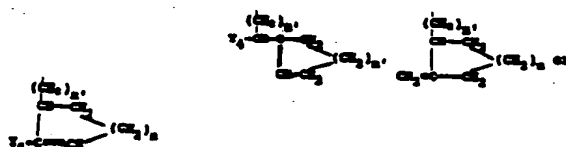
Alternatively, compounds of formula I wherein



can be prepared by first treating a compound of formula II with an alkali metal hydride (e.g., sodium hydride) in an inert organic solvent (e.g., dimethylformamide or dimethylsulfoxide) followed by reaction with the appropriate compound having the formula:

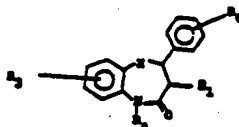


10



The resultant compound has the formula:

IX.

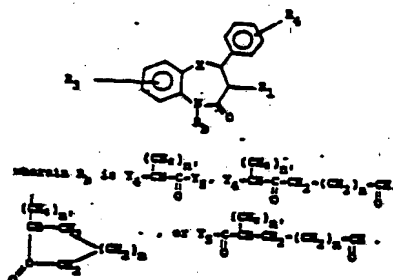


and can be reacted with ozone in an inert solvent (e.g., a halogenated hydrocarbon) followed by reduction (e.g., using a chemical reducing agent such as dimethylsulfide) to yield the corresponding compound having the formula:

15

-22-

X.



A compound of formula X can be treated with the appropriate amine having the formula:

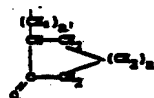
XI. HNY_6Y_7

5 in the presence of a reducing agent (e.g., hydrogen using a catalyst such as palladium on carbon, or a chemical reducing agent such as sodium cyanoborohydride) to obtain the corresponding product of formula I.

It is also possible to obtain an intermediate of

10

formula X wherein R_D is $\text{Y}_4-\text{CH}-\text{C}(\text{Y}_5)=\text{O}$ or



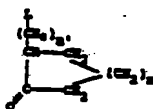
by reacting a compound of formula II with a compound of the formula:

15


XIIa.




XIIb.



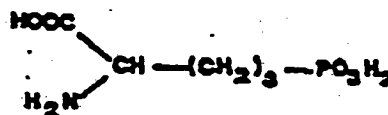
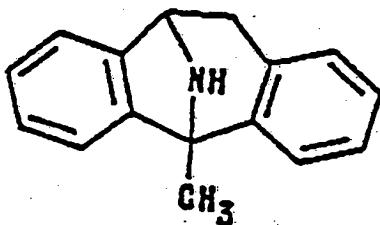
-23-

Compounds of formula I wherein R_2 is  can be synthesized by reaction of a compound of formula II with an alkylating agent, such as chloroacetonitrile to give a compound of formula I wherein R_2 is $-\text{CH}_2\text{CN}$. The resultant compound of formula I wherein R_2 is $-\text{CH}_2\text{CN}$ can be reacted with an alcohol, such as ethanol in the presence of a catalyst, such as hydrochloric acid or sodium ethoxide to give a compound of formula I wherein R_2 is $-\text{CH}_2\text{C}(\text{OEt})=\text{NH}$. Treatment of this compound with a diamine of the formula $\text{H}_2\text{N}-\text{CH}_2(\text{CH}_2)_n\text{NHY}_6$ gives compounds

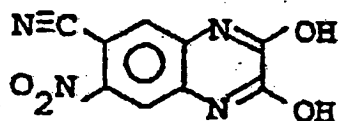
of formula I wherein R_2 is 

Illustrative compounds within this invention are those wherein R_3 is located in the 6- or 7- position of the benzazepine nucleus or the 8- or 9- position of the benzothiazepine nucleus and is halogen, trifluoromethyl or methoxy; and R_4 is located in the 4-position of the phenyl ring to which it is attached and is alkoxy. Included herein are compounds wherein R_3 is 6-trifluoromethyl or 7-methoxy on the benzazepine nucleus, or 8-methoxy on the benzothiazepine nucleus, and R_4 is methoxy.

Excitatory amino acid receptor antagonists include MK-801, 2-APV and CNQX, having the structural formula:



and



respectively.

- 5 Further, the pharmaceutically acceptable salts of any of the above-designated compounds may be employed as the calcium entry blocker in accordance with the invention. Combinations of the aforementioned compounds may likewise be used.
- 10 Calcium entry blockers of this invention may be administered orally, parenterally or topically. In acute situations, parenteral and/or topical administration is preferred in order to more rapidly introduce the calcium

entry blocker to the target site. For chronic therapy, oral administration is normally preferred since it is more easily administered.

5 The compounds for use in this invention are administered in their pure form or in admixture with a pharmaceutically acceptable carrier such as an organic or inorganic solid or liquid excipient (depending on the desired administration). The pharmaceutical preparations may thus be administered as a solid, semi-solid,
10 lyophilized powder, liquid dosage form, tablets, pills, capsules, powders, solutions, suspensions, emulsions, creams, lotions, ointments, or granules, as well as injectable solutions. The nature of the composition in the pharmaceutical carrier or diluent will, of course,
15 depend upon the intended route of administration.

When the pharmaceutical composition is in the form of a solution or suspension, examples of appropriate pharmaceutical carriers or diluents (depending on the intended route of administration) include for aqueous
20 systems, water; for non-aqueous systems, ethanol, glycerin, propylene glycol, corn oil, olive oil, syrup, cottonseed oil, peanut oil, sesame oil, parafins and mixtures thereof with water; and for solid systems, lactose, kaolin, mannitol, sucrose, gelatin and agar.

25 In addition to conventional pharmaceutical carriers or excipients, the pharmaceutical compositions may include other medicinal agents, pharmaceutical agents, adjuvants, stabilizers, anti-oxidants, preservatives, lubricants, suspending agents, and viscosity modifiers, etc.

30 The dosage level of the calcium entry blocker within this invention is dependent upon the conditions of the disease to be treated, the administration route employed, the subject and the pharmacokinetic and pharmacodynamic characteristics of the active ingredient. The dosage of
35 the active ingredient is generally within the range from about 0.1 to about 100 mg/kg administered orally, parenterally or topically.

When administered either parenterally or topically, the physiological pH is generally in the range of about pH 6.5 to 8.

5 Methods are further described for screening compounds capable of reversing retinal malfunction the effect of retinal dysfunction, where an in vivo bioassay is employed involving rats with inducible retinal dysfunction. Specific compounds for treating retinal dysfunction are provided associated with modulation of calcium channel activity and/or the activation of excitatory amino acid 10 receptors. Particularly, calcium channel antagonists or other compounds having equivalent effect (excitatory amino acid antagonists) can be used in the treatment of retinal vasculopathy.

15 One methodology involves the use of Dahl salt-sensitive (SS) rats which are available from Harlan Sprague-Dawley. The rats will generally be in the age group of three to twenty weeks, usually in the age group of four to twelve weeks. When placed on a high salt diet, 20 the animals rapidly develop (2-4 weeks) a systemic hypertension. Other rats which may be used are normal Sprague-Dawley (albino) rats, Long-Evans pigmented rats or spontaneously hypertensive (SHR) (albino) rats.

25 All of these rats may be employed as models by creation of acute retinal ischemia in their eyes. The ischemia may be created by reversibly occluding the short posterior ciliary arteries and the central retinal artery. Electroretinograms are recorded prior to, during and after occlusion. The occlusion is reversed after a brief 30 period, usually one minute to three hours, preferably five minutes to two hours and reperfusion occurs. During reperfusion ERGs are taken to provide an index of retinal function, followed by a histologic examination to determine changes in normal retinal structure. 35 Ophthalmoscopic examination of the eyes is also performed to document the absence of retinal blood flow and gross ischemic damage. Drug efficacy is related to the ability

of the candidate composition to reduce or prevent pathologic changes noted in ERG and histologic examinations.

For histological examination, the eyes may be fixed
5 by cardiac perfusion with a fixative, such as a combination of paraformaldehyde and glutaraldehyde in an appropriate buffer. After removal of the eyes, the globe may be opened at the ora serrata and fixation continued for four to twenty-four hours. Segments of the central
10 and peripheral retinal are then dissected free, the tissue washed and then post fixed in an appropriate fixative, e.g., osmium tetroxide. Following dehydration, the sample may be sectioned in accordance with conventional techniques for light and electron microscopy.

15 Changes in thickness on the retinal layer or number of cell bodies per unit area in the inner and outer nuclear layers may then be observed and reported. In addition, the retinas may be reported as "normal", if all layers are intact with no abnormalities; "mild
20 degeneration", if thinning of the inner and outer segments or visible reduction in cell bodies of the inner and outer nuclear layers has occurred; and "severe degeneration", if extensive loss of any individual or multiple layers of the retina has occurred.

25 To evaluate retinal function, an electroretinogram (ERG) may be employed. Functional assessment of the inner and outer layers of the neural retina and the non-neural retina (RPE) is made by means of full field ERGs. The wave forms of the ERG result from the electrophysiological
30 processes involved in visual transduction in the retina. Reduction in these waves provides a direct measurement of retinal function. The initial negative deflection, termed the "a-wave", originates in the photoreceptors. The subsequent b-wave is produced by the Muller and bipolar
35 cells from the inner retina. The much slower positive c-wave arises from the RPE but is generally reduced or absent in adult albino rats. Whereas the photoreceptors

and RPE are nourished by the choroidal circulation, the Muller and bipolar cells are nourished primarily by the retinal vessels. An initial indication as to the site of retinal ischemia may be related to selective reductions in the individual wave forms.

Base-line ERGs may be obtained prior to induction of retinal ischemia. Thereafter, ERGs are determined at convenient intervals, e.g. hourly, daily or weekly. These subsequent ERGs are then normalized to preischemic values and are expressed as the percent of control (i.e. baseline) values. Prior to dark adaptation, the rat host receives an ophthalmoscopic examination to ensure the absence of cataracts or other gross abnormalities. Since rats are primarily a rod-dominated (98%) animal, ERGs are performed under dark-adapted conditions (12-14 hours). Rats are anesthetized and placed on a heating pad to maintain normal body temperature.

To record ERGs, small agar-Ag/AgCl electrodes are placed on the cornea and tongue. A reference ground electrode is placed under the scalp. ERG signals may be amplified by an appropriate differential amplifier and recorded. Light stimulation is provided by an appropriate photostimulator in conjunction with a series of neutral density filters.

Single flash (10 μ sec duration) of white light is used to generate individual ERGs. The amplitude of the b-waves is measured from base line to peak in the absence of an a-wave or from the trough of the a-wave to the peak of the b-wave. a-Waves are measured from the base line to the peak of the a-wave. The time interval from the onset of the flash to the peak of the a- and b-waves is used for measurements of latency.

Group data are compared by means of a two-way analysis of variance. Comparisons involving two means employ Students t-test for non-paired data. Differences between groups (control vs. drug-treated) are regarded as significant if P-values are ≤ 0.05 .

The following examples are offered by way of illustration and not by way of limitation.

EXPERIMENTAL

The methodology involves the creation of acute
5 retinal ischemia in the eyes of normal Sprague-Dawley
(albino) or Long-Evans (pigmented) rats, which are
available from Harlan Sprague-Dawley. Adult rats were
used, ranging in weight from 175 g to 250 g. These rats
were housed under normal conditions and fed standard rat
10 chow. Rats were anesthetized with 50 mg/kg sodium
pentobarbital intraperitoneally (i.p.) and the iris of the
eye dilated with one drop of 10% atropine solution. Total
retinal ischemia in these animals was created by
reversibly occluding the short posterior ciliary arteries
15 and the central retinal artery. The duration of the
occlusions varied from five to 120 minutes. Prior to the
occlusion, baseline ERGs were recorded and used as an
index of normal retinal function. Complete retinal
occlusion was determined by the absence of ERG. At the
20 end of the occlusion period, the retina was allowed to
reperfuse, and changes in normal retinal structure and
function determined by histological observations and ERGs.
During the reperfusion period, ERGs were evaluated at one
to two minute intervals for the first 30 minutes and
25 thereafter at ten minute intervals through 120 minutes.
Additional, ERG evaluations in selected animals were made
at 24 hours. Drug efficacy was based on the ability of a
compound to minimize or prevent the pathologic changes in
retinal structure and/or function induced by acute retinal
30 ischemia (e.g. the appearance of necrotic cells within the
retina or a significant reduction or loss of normal wave
forms in the ERG.)

Example 1 illustrates an in vivo bioassay which can
be employed for determining the efficacy of compounds in
35 the treatment of retinal dysfunction.

Examples 2-4, conducted in accordance with the
procedure of Example 1, demonstrate that pretreatment with

-30-

Ca⁺⁺ channel antagonists can protect retinal function (as measured by ERG recovery) from ischemic injury. Values are means \pm standard errors and have been normalized (0-100%) to preocclusion control values. At each time point tested, significant improvement in b-wave recovery when compared to control-treated animals is exhibited.

Example 5 is drawn to the use of an excitatory amino acid antagonist.

Example 1

10 The subject invention provides for retinal degeneration models as evidenced by both structural and functional changes. Associated with the retinal dysfunction and/or degeneration is a dramatic reduction in retinal perfusion. These rats are therefore good models for screening compounds having activities as calcium channel antagonists or excitatory amino acid antagonists and their use in preventing or ameliorating retinal degeneration.

20 Four different periods of retinal ischemia in Long-Evans and Sprague-Dawley rats were examined. In normal Sprague-Dawley rats occlusions of five minutes resulted in the rapid return to control level of both a- and b-waves of the ERG, while occlusions of two hours result in the irreversible loss of retinal function, as measured by the ERG. Occlusion for periods between five minutes to two hours in both Long-Evans and Sprague-Dawley rats resulted in a partial but permanent loss of retinal function, that was amenable by drug therapy.

30 Reperfusion following 30 minutes of total retinal ischemia resulted in rapid recovery of the a-wave in one to two minutes. The recovery of the b-wave was considerably different. The b-wave was first observed between 16 and 22 minutes. From this point the b-wave slowly recovered over the next 60 to 120 minutes, but remained significantly reduced from the control levels. By 120 minutes, the b-wave has recovered to approximately 30% of control values. By 24 hours the mean b-wave was

-31-

still only 40% of control values. For shorter periods of occlusion (e.g. 15 minutes), the a-wave again rapidly recovered in one to two minutes. The initial appearance of the b-wave also occurred at 16 to 22 minutes of reperfusion, but the magnitude of the a-wave recovery at 90 minutes and 24 hours was 61% and 100% of control levels (as compared to 26% and 40%, respectively, for the 30 minute occlusion). These data indicate that total retinal ischemia for 30 minutes results in the partial loss of retinal function. This loss appears to be permanent, as the b-wave recovery was only 40% of control values after 24 hours of reperfusion. The rapid return of the a-wave and gradual return of the b-wave indicates that the primary site of acute retina ischemic injury is the inner retinal layer.

Example 2

Long-Evans rats were treated i.p. with control (10% TWEEN 80) or nifedipine 30 minutes prior to the occlusion of retinal vessels.

Table I shows the effect of nifedipine i.p. on b-wave recovery following 30 minutes of total retinal ischemia (*P<0.05).

TABLE I

TIME FROM REPERFUSION (min)	CONTROL (N=7)	1 mg/kg (n=4)	3.3 mg/kg (n=5)	10 mg/kg (n=6)	33 mg/kg (n=5)
30	5 ± 2	13 ± 3*	20 ± 6*	13 ± 2*	15 ± 5*
60	19 ± 4	47 ± 2*	60 ± 9*	39 ± 5*	41 ± 6*
90	28 ± 6	66 ± 2*	81 ± 12*	58 ± 9*	51 ± 6*
120	32 ± 6	72 ± 2*	84 ± 13*	65 ± 11*	54 ± 6*
180	34 ± 5	70 ± 5*	81 ± 9*	67 ± 9*	53 ± 6*

The ability of the 3.3 mg/kg dose to provide apparently better protection of retinal function than the 10 and 33 mg/kg dose likely reflects cardiovascular side effects of nifedipine, as significantly greater reductions in heart rate and blood pressure were observed in these animals. Hence, the resulting dose-related reduction in cardiac output and peripheral vasodilation likely reduces

retinal perfusion in the ischemic eye and reduces functional recovery (e.g. ERG's) of the retina.

Example 3

Long-Evans rats were treated intraperitoneally with either 10% TWEEN 80 as a control or 1,1-Dimethyl-2-[N-(3,3-diphenylpropyl)-N-methyl-amino]ethyl methyl 1,4-dihydro-2,6-dimethyl-4-(3-nitrophenyl)-3,5-pyridine-dicarboxylate hydrochloride 30 minutes prior to the occlusion of retinal vessels. Statistical comparisons were made and the results tabulated at each time point. (*P<0.05).

TABLE II

	TIME FROM REPERFUSION (min)	CONTROL (n=7)	0.33 mg/kg (n=5)
15	30	7.0 ± 2	13 ± 5*
	60	19 ± 3	36 ± 6*
	90	31 ± 2	52 ± 5*
	120	35 ± 2	60 ± 3*
20	180	36 ± 6	64 ± 4*

Example 4

Long-Evans rats were treated with either water (as control) or [3R-[1(S*),3<a,4<a]]-3-(Acetyloxy)-1,3,4,5-tetrahydro-4-(4-methoxyphenyl)-1-(2-pyrrolidinyl-methyl)-6-(trifluoromethyl)-2H-1-benzazepin-2-one, monohydrochloride 30 minutes prior to the occlusion of retinal vessels. Statistical comparisons were made at each time point. See Table III. (*P<0.05).

TABLE III

	TIME FROM REPERFUSION (min)	CONTROL (n=6)	3.3 mg/kg (n=5)
35	30	4 ± 1	11 ± 1*
	60	21 ± 2	36 ± 4*
	90	28 ± 2	54 ± 2*
	120	37 ± 2	63 ± 4*
	180	42 ± 2	74 ± 4*

Example 5

Unlike Ca^{++} channels, which are located in both retinal neurons and vessels, excitatory amino acid receptor are located only in the retina. Hence, the in vitro chick retina assay, an assay independent of retinal blood flow, was used to evaluate these excitatory amino acid receptor antagonists. Chick retinas were isolated from a day 14 embryo. Isolated retinas were then incubated for 40 or 60 minutes in a control Ringer's solution (5 mM glucose under an atmosphere of 95% air, 5% CO_2) or in a test Ringer's solution (0 mM glucose under an atmosphere of 95% N_2 , 5% CO_2). In selected experiments, the NMDA antagonist, MK 801 (10^{-6} to 10^{-4}M), was added to retinas incubated in the test Ringer's solution. At the end of the incubation period retinas were fixed in 4% paraformaldehyde, dehydrated in ethanol and embedded in paraffin. Thick ($4\mu\text{m}$) cross-section of the retina were then cut, stained with haematoxylin and eosin, and evaluated by light microscopy to determine the degree of retinal degeneration.

Control retinas (i.e. incubate in Ringer's with glucose under 95% air) showed no damage or alteration in retinal structure following incubation up to 60 minutes. Retinas incubated in the test Ringer's solution showed signs of cellular degeneration in the ganglionic and inner plexiform layers and edema in the inner nuclear, outer plexiform and inner plexiform layers. The administration of 10^{-6}M to 10^{-4}M MK 801 to retinas incubated in test Ringer's caused a dose related improvement in these structural integrity of the retina, with all layers present in the MK 801-treated retinas, when compared to nontreated retinas. In addition, the edema noted in retinas incubated in the test Ringer's was reduced by the administration of MK 801.

Although the foregoing invention has been described in some detail by way of illustration and example for purposes of clarity of understanding, it will be readily

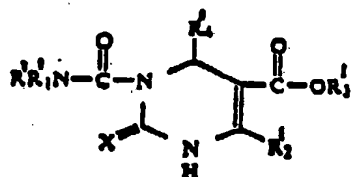
apparent to those of ordinary skill in the art in light of the teachings of this invention that certain changes and modifications may be made thereto without departing from the spirit or scope of the appended claims.

CLAIMS

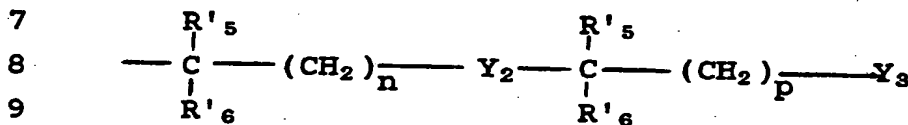
1 1. A method of treating a subject suffering from
2 ischemia or edema of the retina or optic nerve which
3 comprises administering to said subject a therapeutically
4 effective amount of a calcium channel antagonist selected
5 from the group consisting of dihydropyrimidones and
6 benzazepines.

1 2. The method of claim 1, wherein said calcium
2 channel antagonist is a dihydropyrimidone.

1 3. The method of claim 1, wherein said
2 dihydropyrimidone is of the formula:



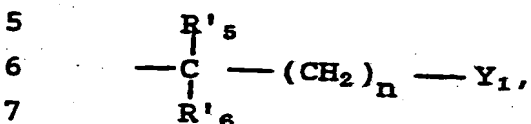
3 and pharmaceutically acceptable salts thereof wherein X is
4 oxygen or sulfur; R' is hydrogen, alkyl, cycloalkyl, aryl,
5 or arylalkyl and R'1 is hydrogen, alkyl, cycloalkyl, aryl,
6 heterocyclo,



10 or halo substituted alkyl, or R' and R'1 taken together
11 with the nitrogen atom to which they are attached are
12 1-pyrrolidinyl, 1-piperidinyl, 1-azepinyl, 4-morpholinyl,
13 4-thiamorpholinyl, 1-piperazinyl, 4-alkyl-1-piperazinyl,
14 4-arylalkyl-1-piperazinyl, 4-diarylalkyl-1-piperazinyl or
15 1-pyrrolidinyl, 1-piperidinyl, or 1-azepinyl substituted

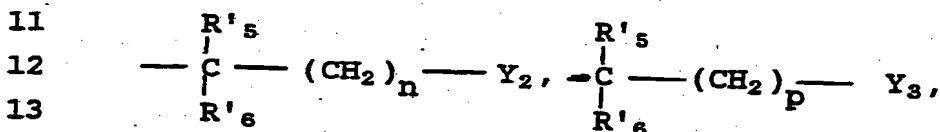
1 with alkyl, alkoxy, alkylthio, halo, trifluoromethyl or
2 hydroxy;

3 R'_2 is hydrogen, alkyl, alkenyl, alkynyl, cycloalkyl,
4 aryl,



8 or halo substituted alkyl;

9 R'_3 is hydrogen, alkyl, cycloalkyl, aryl,
10 heterocyclo,



14 or halo substituted alkyl;

15 R'_4 is aryl or heterocyclo;

16 R'_5 and R'_6 are each independently hydrogen, alkyl,

17 $-(CH_2)_q-$ aryl or $-(CH_2)_q-$ cycloalkyl;

18 Y_1 is cycloalkyl, aryl, heterocyclo, hydroxyl, alkoxy,

19 aryl $-(CH_2)_m-O-$, mercapto, alkylthio,

20 aryl $-(CH_2)_m-S-$, amino, substituted amino,

21 carbamoyl,

22
$$(Substituted\ amino)-\overset{O}{\parallel}C-, heterocyclo-(CH_2)_m-\overset{O}{\parallel}C-$$

24
$$carboxyl, alkoxy carbonyl, alkyl-\overset{O}{\parallel}C-, aryl-(CH_2)_m-\overset{O}{\parallel}C-$$

26
$$alkyl-\overset{O}{\parallel}C-O- \text{ or } aryl-(CH_2)_m-\overset{O}{\parallel}C-O-$$

28 Y_2 is cycloalkyl, aryl, heterocyclo, carbamoyl,

29
$$(substituted\ amino)-\overset{O}{\parallel}C-, carboxyl, alkoxy carbonyl,$$

31
$$alkyl-\overset{O}{\parallel}C-, aryl-(CH_2)_m-C- \text{ or } heterocyclo-(CH_2)_m-\overset{O}{\parallel}C-;$$

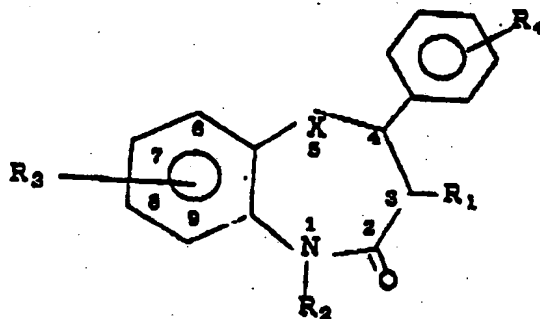
33 Y_3 is hydroxyl, alkoxy, aryl $-(CH_2)_m-O-$, mercapto,

-37-

- 1 alkylthio, aryl-(CH₂)_m-S-,
 2
 3 alkyl-C(=O)-O-, aryl-(CH₂)_m-C(=O)-O-,
 4 amino or substituted amino;
 5 q is 0, 1, 2 or 3;
 6 m is 0 or an integer of 1 to 6;
 7 n is 0 or an integer of 1 to 5; and
 8 p is an integer of 1 to 5.

- 1 4. The method of claim 3, wherein said
 2 dihydropyrimidone is
 3 (R)-1-(aminocarbonyl)-6-(3-chlorophenyl)-1,2,3,6-
 4 tetrahydro-4-methyl-2-oxo-5-pyrimidine carboxylic acid,
 5 1-methylethyl ester.

- 1 5. The method of claim 1, wherein said calcium
 2 channel antagonist is a benzazepine of the formula:

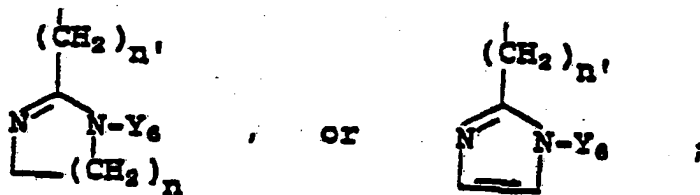
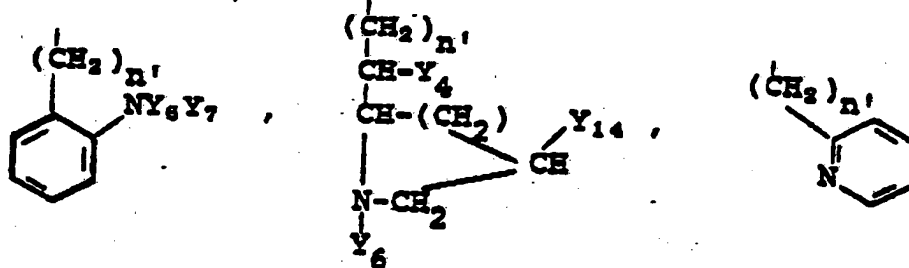
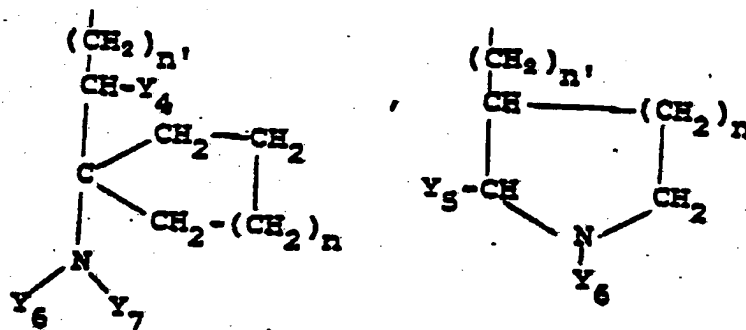
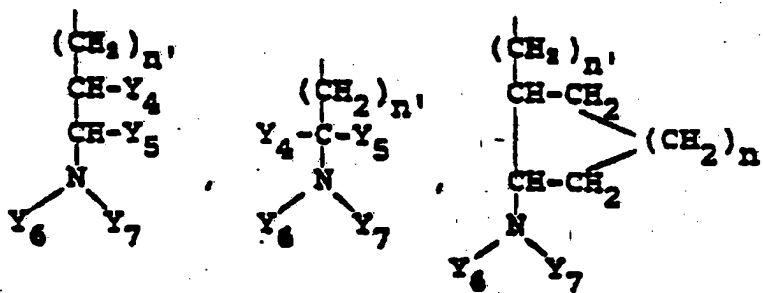


- 3 and the pharmaceutically acceptable salts thereof,
 4 wherein:

- 5 X is -CH₂-;

- 6
 7 R₁ is $\begin{array}{c} Y_1 \\ | \\ -CH \\ | \\ Y_2 \end{array}$ or -O-Y₃;
 8

- 9 when X is -CH₂-, R₂ is



1 R_3 and R_4 are each independently hydrogen, halogen,
 2 alkyl, alkoxy, aryloxy, arylalkoxy, arylalkyl, cyano,
 3 hydroxy, alkanoyloxy,

4 -O-C(=O)-NY_9 , fluoro substituted alkoxy, fluoro substituted
 5 alkyl, (cycloalkyl)alkoxy, -NO_2 ,

7 $\text{-NY}_{10}\text{Y}_{11}$, $\text{-S(O)}_m\text{alkyl}$, $\text{-S(O)}_m\text{aryl}$, -C(=O)-Y_{12} or
 8

9 -O-C(=O)-Y_{13} ;
 10

11 n or n' are independently 0, 1, 2, or 3;
 12 m is 0, 1 or 2;

13 Y_1 and Y_2 are independently hydrogen or alkyl, Y_1 is
 14 hydrogen and Y_2 is alkenyl, alkynyl, aryl, heteroaryl, or
 15 cycloalkyl, or Y_1 and Y_2 together with the carbon atom to
 16 which they are attached are cycloalkyl;

17 Y_3 is hydrogen, alkyl, alkanoyl, alkenyl,
 18 arylcarbonyl,
 19 heteroarylcarbonyl, or $\text{-C(=O)-NY}_8\text{Y}_9$;

20 Y_4 and Y_5 are each independently hydrogen, alkyl,
 21 aryl or arylalkyl, provided that when both are present
 22 they are not both hydrogen, and provided further that when
 23 both are attached to the same carbon atom neither of them
 24 is hydrogen;

25 Y_6 and Y_7 are each independently hydrogen, alkyl,
 26 cycloalkyl or arylalkyl or Y_6 and Y_7 together with the
 27 nitrogen atom to which they are attached are azetidiny,
 28 pyrrolidinyl, piperidinyl, or morpholinyl;

29 Y_8 and Y_9 are each independently hydrogen, alkyl,
 30 aryl or heteroaryl, or Y_8 and Y_9 together with the
 31 nitrogen atom to which they are attached are pyrrolidinyl,
 32 piperidinyl or morpholinyl;

33 Y_{10} and Y_{11} are each independently hydrogen, alkyl,
 34 alkanoyl, arylcarbonyl, heteroarylcarbonyl,

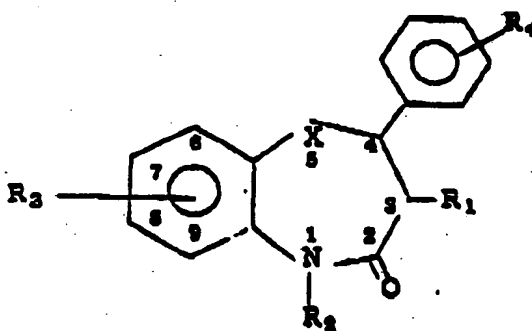
- 1 O
2 or $-\text{C}-\text{NY}_8\text{Y}_9$;
3 Y_{12} is hydroxy, alkoxy, aryloxy, amino, alkylamino or
4 dialkylamino;
5 Y_{13} is alkyl, alkoxy, or aryloxy; and
6 Y_{14} is hydrogen, hydroxy, alkoxy, aryloxy or
7 arylalkoxy.

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1 6. The method of claim 5, wherein said benzazepine
2 is selected from the group consisting of
3 [3R-[1(S*),3<a,4<a]]-3-(Acetyloxy)-1,3,4,5-tetrahydro-4-
4 (4-methoxyphenyl)-1-(2-pyrrolidinylmethyl)-6-
5 (trifluoromethyl)-2H-1-benzazepin-2-one,
6 monohydrochloride.

1 7. The method of claim 1, wherein said benzazepine
2 is
3 (3R-cis)-3-(Acetyloxy)-1-[2-(dimethylamino)ethyl]-1,3,4,5-
4 tetrahydro-4-(4-methoxyphenyl)-6-(trifluoromethyl)-2H-1-
5 benzazepin-2-one, monohydrochloride.

1 8. A method of treating a subject suffering from
2 ischemia or edema of the retina or optic nerve which
3 comprises administering to said subject a therapeutically
4 effective amount of a benzothiazepine derivative of the
5 formula:

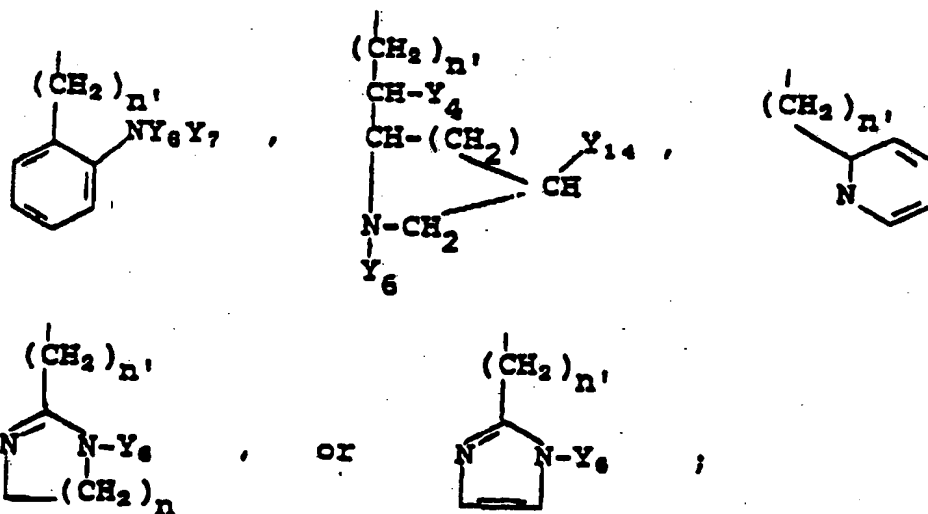
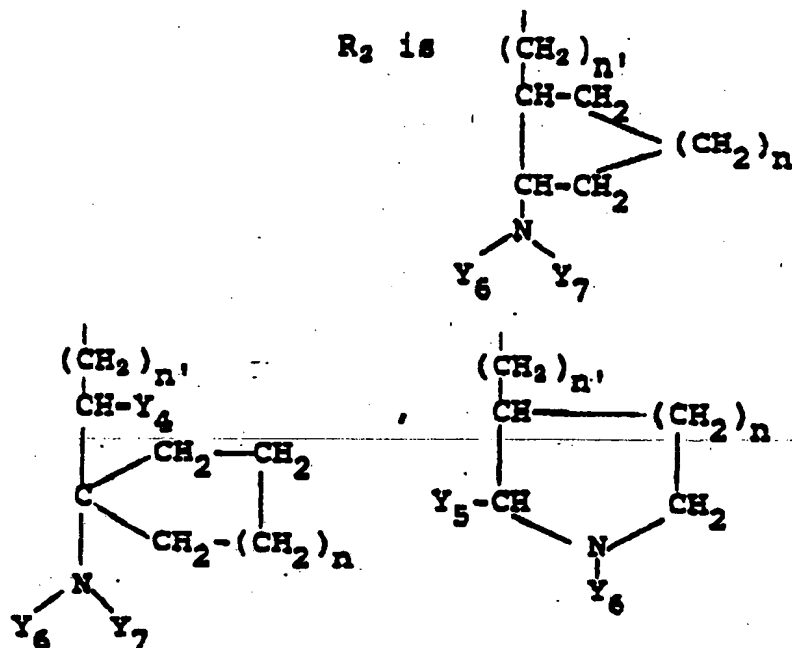


6 and the pharmaceutically acceptable salts thereof,
7 wherein:
8 X is -S-;

1
2
3

$$R_1 \text{ is } \begin{array}{c} Y_1 \\ | \\ -CH \\ | \\ Y_2 \end{array} \text{ or } -O-Y_3;$$

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1 R_3 and R_4 are each independently hydrogen, halogen,
 2 alkyl, alkoxy, aryloxy, arylalkoxy, arylalkyl, cyano,
 3 hydroxy, alkanoyloxy,

4 $\text{-O}-\overset{\text{O}}{\parallel}\text{C}-\text{NY}_9$, fluoro substituted alkoxy, fluoro substituted
 5 alkyl, (cycloalkyl)alkoxy, $-\text{NO}_2$,

7 $-\text{NY}_{10}\text{Y}_{11}$, $-\text{S}(\text{O})_m\text{alkyl}$, $-\text{S}(\text{O})_m\text{aryl}$, $-\overset{\text{O}}{\parallel}\text{C}-\text{Y}_{12}$ or
 8

9 $-\overset{\text{O}}{\parallel}\text{C}-\text{Y}_{13}$;
 10

11 n or n' are independently 0, 1, 2, or 3;

12 m is 0, 1 or 2;

13 Y_1 and Y_2 are independently hydrogen or alkyl, Y_1 is
 14 hydrogen and Y_2 is alkenyl, alkynyl, aryl, heteroaryl, or
 15 cycloalkyl, or Y_1 and Y_2 together with the carbon atom to
 16 which they are attached are cycloalkyl;

17 Y_3 is hydrogen, alkyl, alkanoyl, alkenyl,
 18 arylcarbonyl,
 19 heteroarylcarbonyl, or $-\overset{\text{O}}{\parallel}\text{C}-\text{NY}_8\text{Y}_9$;

20 Y_4 and Y_5 are each independently hydrogen, alkyl,
 21 aryl or arylalkyl, provided that when both are present
 22 they are not both hydrogen, and provided further that when
 23 both are attached to the same carbon atom neither of them
 24 is hydrogen;

25 Y_6 and Y_7 are each independently hydrogen, alkyl,
 26 cycloalkyl or arylalkyl or Y_6 and Y_7 together with the
 27 nitrogen atom to which they are attached are azetidiny,
 28 pyrrolidinyl, piperidinyl, or morpholinyl;

29 Y_8 and Y_9 are each independently hydrogen, alkyl,
 30 aryl or heteroaryl, or Y_8 and Y_9 together with the
 31 nitrogen atom to which they are attached are pyrrolidinyl,
 32 piperidinyl or morpholinyl;

33 Y_{10} and Y_{11} are each independently hydrogen, alkyl,
 34 alkanoyl, arylcarbonyl, heteroarylcarbonyl,

-45-

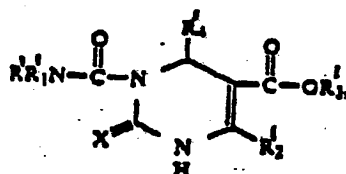
- 1 O
2 or -C-NY₈Y₉;
3 Y₁₂ is hydroxy, alkoxy, aryloxy, amino, alkylamino or
4 dialkylamino;
5 Y₁₃ is alkyl, alkoxy, or aryloxy; and
6 Y₁₄ is hydrogen, hydroxy, alkoxy, aryloxy or
7 arylalkoxy.

1 9. The method of claim 1, wherein said compound is
2 administered topically, parenterally or orally.

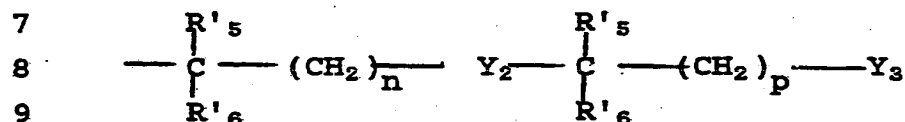
1 10. A method of preventing ischemia or edema of the
2 retina or optic nerve which comprises administering to a
3 subject a prophylactically effective amount of a calcium
4 channel antagonist selected from the group consisting of
5 dihydropyrimidones and benzazepines.

1 11. The method of claim 10, wherein said calcium
2 channel antagonist is a dihydropyrimidone.

1 12. The method of claim 11, wherein said
2 dihydropyrimidone is of the formula:



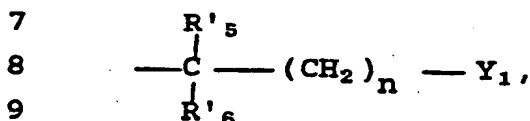
3 and pharmaceutically acceptable salts thereof wherein X is
4 oxygen or sulfur; R' is hydrogen, alkyl, cycloalkyl, aryl,
5 or arylalkyl and R'₁ is hydrogen, alkyl, cycloalkyl, aryl,
6 heterocyclo,



10 or halo substituted alkyl, or R' and R', taken together
11 with the nitrogen atom to which they are attached are
12 1-pyrrolidinyl, 1-piperidinyl, 1-azepinyl, 4-morpholinyl,
13 4-thiamorpholinyl, 1-piperazinyl, 4-alkyl-1-piperazinyl,

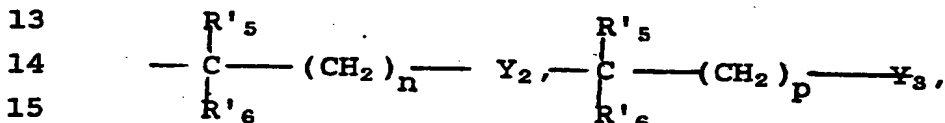
1 4-arylalkyl-1-piperazinyl, 4-diarylalkyl-1-piperazinyl or
 2 1-pyrrolidinyl, 1-piperidinyl, or 1-azepinyl substituted
 3 with alkyl, alkoxy, alkylthio, halo, trifluoromethyl or
 4 hydroxy;

5 R'_2 is hydrogen, alkyl, alkenyl, alkynyl, cycloalkyl,
 6 aryl,



10 or halo substituted alkyl;

11 R'_3 is hydrogen, alkyl, cycloalkyl, aryl,
 12 heterocyclo,



16 or halo substituted alkyl;

17 R'_4 is aryl or heterocyclo;

18 R'_5 and R'_6 are each independently hydrogen, alkyl,

19 $-(CH_2)_q-$ aryl or $-(CH_2)_q-$ cycloalkyl;

20 Y_1 is cycloalkyl, aryl, heterocyclo, hydroxyl, alkoxy,

21 aryl $-(CH_2)_m-O-$, mercapto, alkylthio,

22 aryl $-(CH_2)_m-S-$, amino, substituted amino,

23 carbamoyl,

24
$$\begin{array}{c} O \\ || \\ (Substituted\ amino)-C- \end{array}, \begin{array}{c} O \\ || \\ heterocyclo-(CH_2)_m-C- \end{array}$$

26
$$\begin{array}{c} O \\ || \\ carboxyl, \end{array} \begin{array}{c} O \\ || \\ alkoxy\ carbonyl, \end{array} \begin{array}{c} O \\ || \\ alkyl-C- \end{array}, \begin{array}{c} O \\ || \\ aryl-(CH_2)_m-C- \end{array}$$

28
$$\begin{array}{c} O \\ || \\ alkyl-C-O- \end{array} \text{ or } \begin{array}{c} O \\ || \\ aryl-(CH_2)_m-C-O- \end{array}$$

30 Y_2 is cycloalkyl, aryl, heterocyclo, carbamoyl,

31
$$\begin{array}{c} O \\ || \\ (substituted\ amino)-C- \end{array}, \begin{array}{c} O \\ || \\ carboxyl, \end{array} \begin{array}{c} O \\ || \\ alkoxy\ carbonyl, \end{array}$$

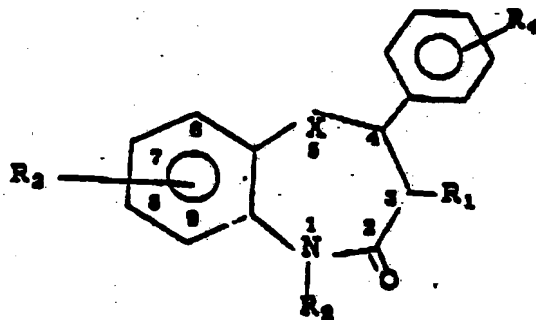
33

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- 1 alkyl-C(=O)-, aryl-(CH₂)_m-C(=O)- or heterocyclo-(CH₂)_m-C(=O)-;
 2 Y₃ is hydroxyl, alkoxy, aryl-(CH₂)_m-O-, mercapto,
 3 alkylthio, aryl-(CH₂)_m-S-,
 4
 5 alkyl-C(=O)-O-, aryl-(CH₂)_m-C(=O)-O-,
 6 amino or substituted amino;
 7 q is 0, 1, 2 or 3;
 8 m is 0 or an integer of 1 to 6;
 9 n is 0 or an integer of 1 to 5; and
 10 p is an integer of 1 to 5.

- 1 13. The method of claim 12, wherein said
 2 dihydropyrimidone is
 3 (R)-1-(aminocarbonyl)-6-(3-chlorophenyl)-1,2,3,6-
 4 tetrahydro-4-methyl-2-oxo-5-pyrimidine carboxylic acid,
 5 1-methylethyl ester.

- 1 14. The method of claim 10, wherein said calcium
 2 channel antagonist is a benzazepine of the formula:



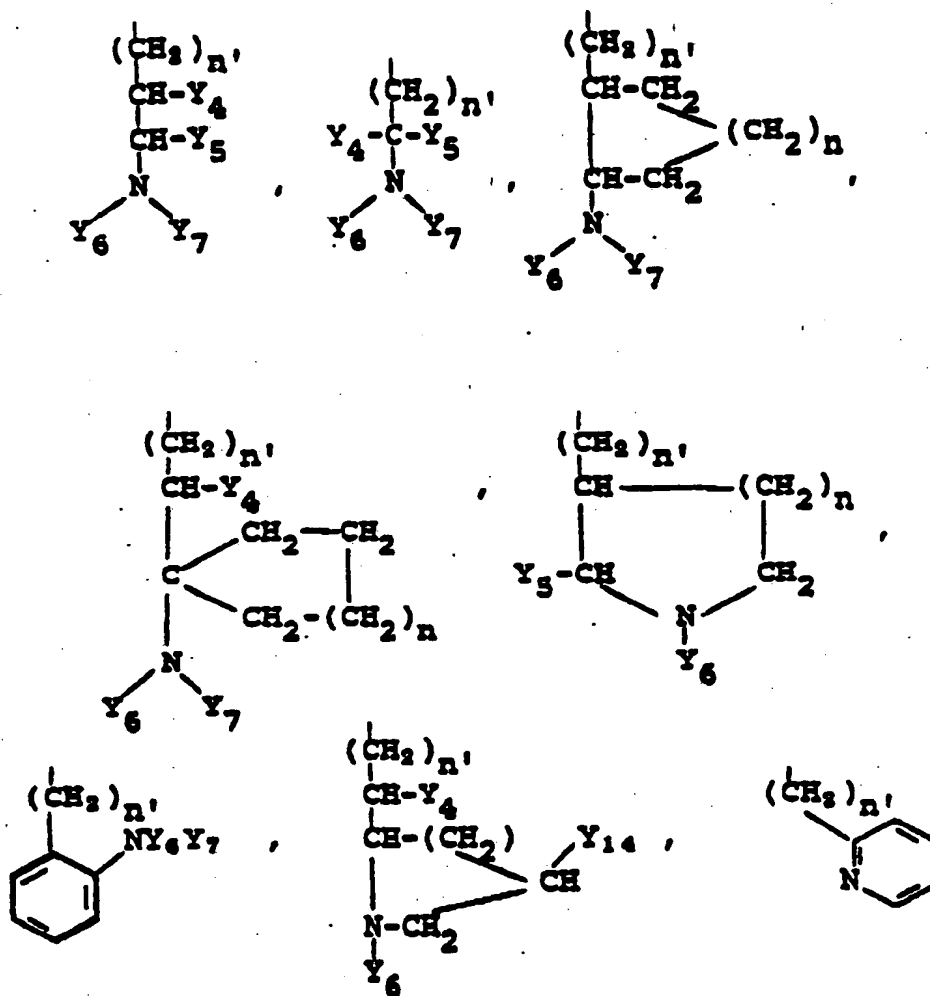
- 3 and the pharmaceutically acceptable salts thereof,
 4 wherein:

- 5 X is -CH₂-;

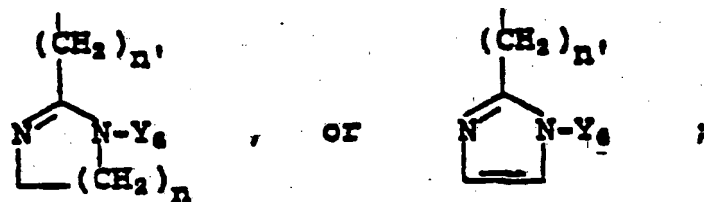
- 6
 7 R₁ is $\begin{array}{c} \text{Y}_1 \\ | \\ -\text{CH}- \\ | \\ \text{Y}_2 \end{array}$ or -O-Y₃;
 8

-49-

1

 R_2 is

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- 1 R_3 and R_4 are each independently hydrogen, halogen,
- 2 alkyl, alkoxy, aryloxy, arylalkoxy, arylalkyl, cyano,
- 3 hydroxy, alkanoyloxy,

1 O
 2 -O-C-NY_9 , fluoro substituted alkoxy, fluoro substituted
 3 alkyl, (cycloalkyl)alkoxy, -NO_2 ,

4 O
 5 $\text{-NY}_{10}\text{Y}_{11}$, $\text{-S(O)}_m\text{alkyl}$, $\text{-S(O)}_m\text{aryl}$, -C-Y_{12} or

6 O
 7 -O-C-Y_{13} ;

8 n or n' are independently 0, 1, 2, or 3;

9 m is 0, 1 or 2;

10 Y_1 and Y_2 are independently hydrogen or alkyl, Y_1 is
 11 hydrogen and Y_2 is alkenyl, alkynyl, aryl, heteroaryl, or
 12 cycloalkyl, or Y_1 and Y_2 together with the carbon atom to
 13 which they are attached are cycloalkyl;

14 Y_3 is hydrogen, alkyl, alkanoyl, alkenyl,

15 arylcarbonyl,
 16 heteroarylcarbonyl, or $\text{-C-NY}_8\text{Y}_9$;

17 Y_4 and Y_5 are each independently hydrogen, alkyl,
 18 aryl or arylalkyl, provided that when both are present
 19 they are not both hydrogen, and provided further that when
 20 both are attached to the same carbon atom neither of them
 21 is hydrogen;

22 Y_6 and Y_7 are each independently hydrogen, alkyl,
 23 cycloalkyl or arylalkyl or Y_6 and Y_7 together with the
 24 nitrogen atom to which they are attached are azetidiny,
 25 pyrrolidinyl, piperidinyl, or morpholinyl;

26 Y_8 and Y_9 are each independently hydrogen, alkyl,
 27 aryl or heteroaryl, or Y_8 and Y_9 together with the
 28 nitrogen atom to which they are attached are pyrrolidinyl,
 29 piperidinyl or morpholinyl;

30 Y_{10} and Y_{11} are each independently hydrogen, alkyl,
 31 alkanoyl, arylcarbonyl, heteroarylcarbonyl,

32 O
 33 or $\text{-C-NY}_8\text{Y}_9$;

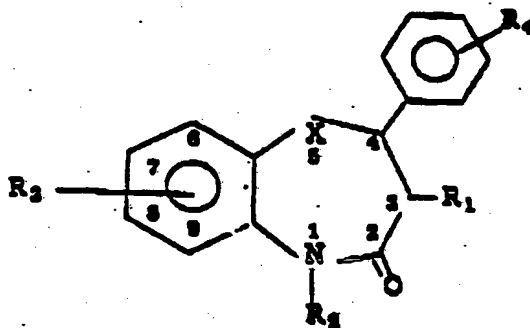
34 Y_{12} is hydroxy, alkoxy, aryloxy, amino, alkylamino or
 35 dialkylamino;

1 Y₁₃ is alkyl, alkoxy, or aryloxy; and
2 Y₁₄ is hydrogen, hydroxy, alkoxy, aryloxy or
3 arylalokoxy.

1 15. The method of claim 14, wherein said
2 benzazepine is
3 [3R-[1(S*),3<a,4<a]]-3-(Acetyloxy)-1,3,4,5-tetrahydro-4-
4 (4-methoxyphenyl)-1-(2-pyrrolidinylmethyl)-6-
5 (trifluoromethyl)-2H-1-benzazepin-2-one, monohydrochloride.

1 16. The method of claim 10, wherein said
2 benzazepine is
3 (3R-cis)-3-(Acetyloxy)-1-[2-(dimethylamino)ethyl]-1,3,4,5-
4 tetrahydro-4-(4-methoxyphenyl)-6-(trifluoromethyl)-2H-1-
5 benzazepin-2-one, monohydrochloride.

1 17. A method or preventing ischemia or edema of the
2 retina or optic nerve which comprises administering to a
3 subject a prophylactically effective amount of a
4 benzothiazepine derivative of the formula:



1 and the pharmaceutically acceptable salts thereof,

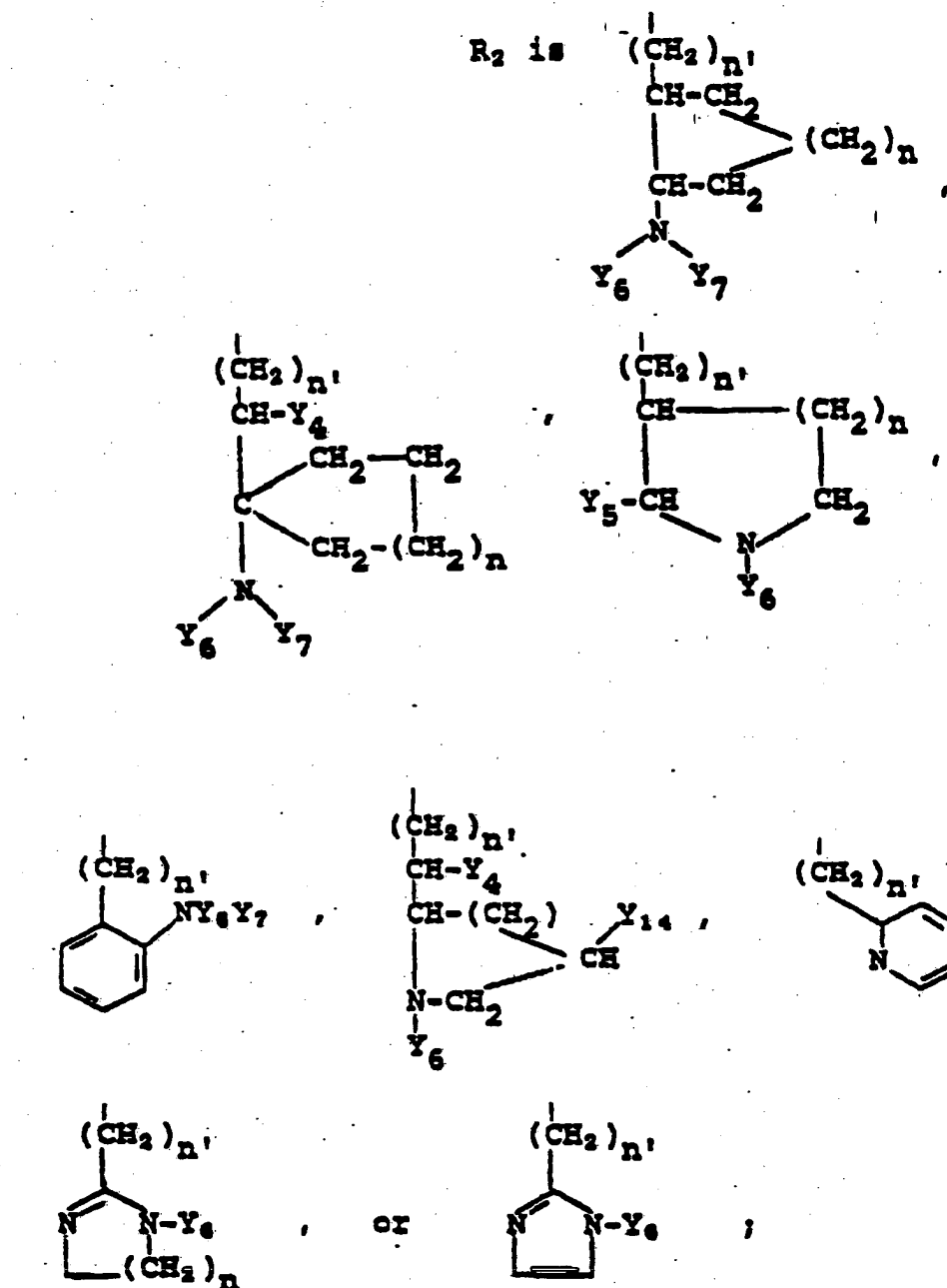
2 wherein:

3 X is -S-;

4 $\begin{array}{c} Y_1 \\ | \\ R_1 \text{ is } -CH \text{ or } -O-Y_3 \\ | \\ Y_2 \end{array}$

6

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2. R₃ and R₄ are each independently hydrogen, halogen,
3 alkyl, alkoxy, aryloxy, arylalkoxy, arylalkyl, cyano,
4 hydroxy, alkanoyloxy,
5 -O-C(=O)-NY_9 , fluoro substituted alkoxy, fluoro substituted
6 alkyl, (cycloalkyl)alkoxy, -NO₂,
7

1
2 $-NY_{10}Y_{11}$, $-S(O)_m$ alkyl, $-S(O)_m$ aryl, $-\overset{\overset{O}{\parallel}}{C}-Y_{12}$ or

3
4 $-\overset{\overset{O}{\parallel}}{C}-Y_{13}$;

5 n or n' are independently 0, 1, 2, or 3;

6 m is 0, 1 or 2;

7 Y_1 and Y_2 are independently hydrogen or alkyl, Y_1 is
8 hydrogen and Y_2 is alkenyl, alkynyl, aryl, heteroaryl, or
9 cycloalkyl, or Y_1 and Y_2 together with the carbon atom to
10 which they are attached are cycloalkyl;

11 Y_3 is hydrogen, alkyl, alkanoyl, alkenyl,

12
13 arylcarbonyl, heteroarylcarbonyl, or $-\overset{\overset{O}{\parallel}}{C}-NY_8Y_9$;

14 Y_4 and Y_5 are each independently hydrogen, alkyl,
15 aryl or arylalkyl, provided that when both are present
16 they are not both hydrogen, and provided further that when
17 both are attached to the same carbon atom neither of them
18 is hydrogen;

19 Y_6 and Y_7 are each independently hydrogen, alkyl,
20 cycloalkyl or arylalkyl or Y_6 and Y_7 together with the
21 nitrogen atom to which they are attached are azetidiny,
22 pyrrolidinyl, piperidinyl, or morpholinyl;

23 Y_8 and Y_9 are each independently hydrogen, alkyl,
24 aryl or heteroaryl, or Y_8 and Y_9 together with the
25 nitrogen atom to which they are attached are pyrrolidinyl,
26 piperidinyl or morpholinyl;

27 Y_{10} and Y_{11} are each independently hydrogen, alkyl,
28 alkanoyl, arylcarbonyl, heteroarylcarbonyl,

29
30 or $-\overset{\overset{O}{\parallel}}{C}-NY_8Y_9$;

31 Y_{12} is hydroxy, alkoxy, aryloxy, amino, alkylamino or
32 dialkylamino;

33 Y_{13} is alkyl, alkoxy, or aryloxy; and

34 Y_{14} is hydrogen, hydroxy, alkoxy, aryloxy or
35 arylalkoxy.

INTERNATIONAL SEARCH REPORT

International Application No. **PCT/US89/05505**

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶ According to International Patent Classification (IPC) or to both National Classification and IPC IPC(5): A61K 31/55, A61K 31/50, A61K 31/495, A61K 31/505, A61K 31/535 U.S.: 514/212, 514/252, 514/275. 514/231.5. 514/227.8 514/211, 514/213																	
II. FIELDS SEARCHED <div style="text-align: center; border-top: 1px solid black; border-bottom: 1px solid black;">Minimum Documentation Searched ⁷</div> <table style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 25%; border-bottom: 1px solid black;">Classification System</th> <th style="border-bottom: 1px solid black;">Classification Symbols</th> </tr> <tr> <td style="border-right: 1px solid black; padding: 5px; vertical-align: top;">U.S.</td> <td style="padding: 5px;">154/212, 514/275, 514/231.5, 514/227.8, 514/252</td> </tr> </table> <div style="text-align: center; border-top: 1px solid black; border-bottom: 1px solid black;">Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸</div>			Classification System	Classification Symbols	U.S.	154/212, 514/275, 514/231.5, 514/227.8, 514/252											
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U.S.	154/212, 514/275, 514/231.5, 514/227.8, 514/252																
CAS-on line: (Calcium (w) channel:) and (Retin? or Ophthalm?)																	
III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹ <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 10%; border-bottom: 1px solid black;">Category ¹⁰</th> <th style="border-bottom: 1px solid black;">Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²</th> <th style="width: 15%; border-bottom: 1px solid black;">Relevant to Claim No. ¹³</th> </tr> </thead> <tbody> <tr> <td style="text-align: center; vertical-align: top;">Y</td> <td style="padding: 5px;">Avery's Drug Treatment, 3rd edition, pages 683 and 698-700 (1987). See page 683, table II and page 698, column 2 through page 700 column 2.</td> <td style="text-align: center; vertical-align: top;">1-17 1-17</td> </tr> <tr> <td style="text-align: center; vertical-align: top;">Y</td> <td style="padding: 5px;">Angiology, volume 33, pages 37-45 (1982) Nihard, P., "Effect of Calcium-Entry-Blockers on Arterioles, Capillaries and Venules of the Retina." See page 38.</td> <td></td> </tr> <tr> <td style="text-align: center; vertical-align: top;">Y</td> <td style="padding: 5px;">Am J Cardiol 1987; 59: 11B-23B, Godfraind, Theophile. "Classification of Calcium Antagonists." See page 12B, table 1 and page 13B, figure 2.</td> <td style="text-align: center; vertical-align: top;">1-17</td> </tr> <tr> <td style="text-align: center; vertical-align: top;">Y</td> <td style="padding: 5px;">US, A, 4,694,002 (FLOYD ET AL) 15 September 1987 See the abstract</td> <td style="text-align: center; vertical-align: top;">1-17</td> </tr> </tbody> </table>			Category ¹⁰	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³	Y	Avery's Drug Treatment, 3rd edition, pages 683 and 698-700 (1987). See page 683, table II and page 698, column 2 through page 700 column 2.	1-17 1-17	Y	Angiology, volume 33, pages 37-45 (1982) Nihard, P., "Effect of Calcium-Entry-Blockers on Arterioles, Capillaries and Venules of the Retina." See page 38.		Y	Am J Cardiol 1987; 59: 11B-23B, Godfraind, Theophile. "Classification of Calcium Antagonists." See page 12B, table 1 and page 13B, figure 2.	1-17	Y	US, A, 4,694,002 (FLOYD ET AL) 15 September 1987 See the abstract	1-17
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<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>¹⁰ Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&" document member of the same patent family</p> </div> </div>																	
IV. CERTIFICATION <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; border-bottom: 1px solid black; vertical-align: bottom;"> Date of the Actual Completion of the International Search 07 MARCH 1990 </td> <td style="width: 50%; border-bottom: 1px solid black; vertical-align: bottom;"> Date of Mailing of this International Search Report <div style="text-align: center; font-size: 1.2em; font-weight: bold;">27 MAR 1990</div> </td> </tr> <tr> <td style="border-bottom: 1px solid black; vertical-align: bottom;"> International Searching Authority ISA/US </td> <td style="border-bottom: 1px solid black; vertical-align: bottom;"> Signature of Authorized Officer <div style="text-align: center;"> RAYMOND J. HENLEY III </div> </td> </tr> </table>			Date of the Actual Completion of the International Search 07 MARCH 1990	Date of Mailing of this International Search Report <div style="text-align: center; font-size: 1.2em; font-weight: bold;">27 MAR 1990</div>	International Searching Authority ISA/US	Signature of Authorized Officer <div style="text-align: center;"> RAYMOND J. HENLEY III </div>											
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